The use of surface nuclear magnetic resonance for the long-term monitoring of groundwater levels: new developments in data acquisition, processing and interpretation methods.

Surface nuclear magnetic resonance (SNMR) is a promising method for the quantitative evaluation and monitoring of groundwater resources, mostly because it yields a geophysical signal directly linked to the amount of groundwater present in the subsurface, which is often complementary to other near-surface geophysical data sets such as electrical conductivity, seismic velocity, or rock density spatial distributions.

The use of this method for the indirect, long-term monitoring of groundwater levels could provide several advantages over classical monitoring techniques which require drilling, equipping and maintaining a well. First, in addition to piezometric levels, the method can also provide direct quantitative information and estimate some hydrodynamics characteristics of the aquifer. Then, the method is non-destructive, thus eliminating the risk of groundwater contamination through the well and finally, it may be cheaper to display and maintain.

The implementation of SNMR as a long-term monitoring tool raises challenges but also opens up opportunities. Indeed, the data acquisition process and the data interpretation strategy must be adapted to the determination of the piezometric level, as accurately as possible, and not only to the approximate location of aquifers. To do so, we study specific loop settings such as the multi-central loop configuration (Kremer et al., 2018a). For data interpretation, we combine the use of classical inversion methods with a promising method called the Bayesian Evidential Learning 1D (BEL1D, Michel et al. 2018, 2019). This new way to interpret geophysical data is based on the analysis of statistical relationships between simulated models and data. In particular, it enables an explicit quantification of the uncertainty on the model parameters used to explain the data, ensuring a safe interpretation.

Second, the context of displaying an SNMR device for a long duration opens up new possibilities regarding the ways to manage, understand and remove the electromagnetic (EM) noise from the acquisition signal. We can consider for instance the use of permanent shielding structures, specially designed to isolate the acquisition loop from a significant part of the EM noise. Also, focusing on a specific site allows for a full characterization of the local EM noise in terms of spatial distribution and evolution in time, enabling the development of new processing strategies that could not be implemented in a daily survey.

Kremer, T., Michel, H., Müller-Petke, M., Irons, T., Hermans, T., Duglosch, R., Nguyen, F. (2018a, Poster presentation) Improving the accuracy of 1D SNMR surveys using the multi-central-loop configuration. *Proceedings of the 31st SAGEEP conference, Nashville (US)* – Poster presentation - http://hdl.handle.net/2268/222280.

Michel, H. (2018). Inversion and Prediction-Focused Approach (PFA) imaging of multiple loops Surface Nuclear Magnetic Resonance (SNMR) data. *Master thesis. University of Liege.* http://hdl.handle.net/2268.2/4549

Michel, H., Hermans, T., & Nguyen, F. (2019). 1D geological modeling of the subsurface from geophysical data with Bayesian Evidential Learning. In *EGU General Assembly 2019* (Vol. 21). http://hdl.handle.net/2268/238241